A COUNTING-ATTACHMENT FOR THE PENDULUM-CHRONOSCOPE.

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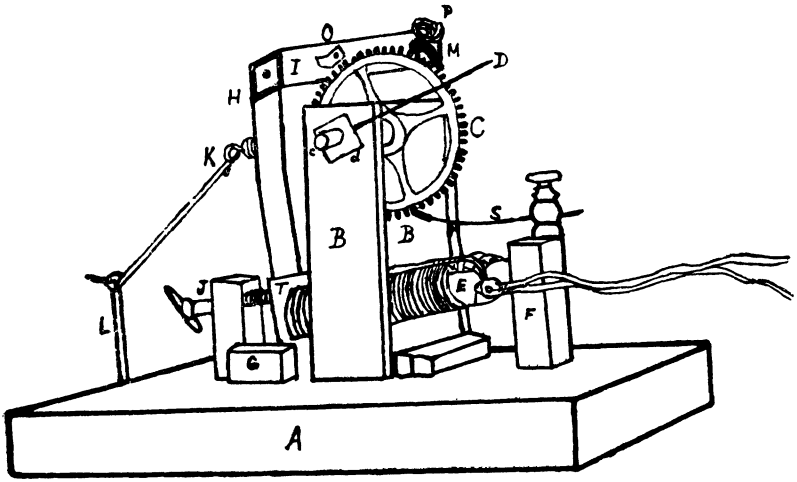
In the April number of this JOURNAL Dr. E. C. Sanford described a form of chronoscope in which the principle of the vernier is applied to the exact measurement of time, and the present apparatus is simply an addition to his chronoscope by which the beats of the slower pendulum are recorded mechanically and indicated on a dial. The counting-attachment is simple and inexpensive, and may easily be made without the assistance of a mechanic.

The principle of the apparatus is simply that every time the slower pendulum reaches the middle of its arc it makes an electric circuit (independent of those mentioned by Sanford), sending the current through an electro-magnet which pulls forward the arm of a lever, which in its turn shoves forward a cog of a cog-wheel, on the axis of which is attached a second-hand moving over a dial. When the pendulum swings past its centre the circuit is again broken and a spring pulls the lever back to its original position.



The construction of such an instrument is very simple, and the cost trifling, one dollar being sufficient to cover every-

thing, even if the materials have to be bought new—fifty cents for a small electro-magnet, twenty cents for two binding posts, leaving thirty cents for a cog-wheel and necessary sheet brass and tin. The base of the instrument, *A*, consists of a piece of pine board 7 inches square, and on this are two wooden uprights, *BB*, $3\frac{3}{4}$ inches high, 1 inch wide, $\frac{3}{8}$ of an inch thick, and $2\frac{1}{2}$ inches apart. These support a cog-wheel, *C*, having sixty cogs, which was taken from an old clock. On the axis, *c*, of the wheel is a piece of small wire 2 inches long, serving as a second-hand; the wire is supported by a small wooden nut, *d*, which is made to slip off and on the axis easily, but with sufficient friction to keep it in place. The dial is not shown in the diagram, as it would prevent a view of the working parts of the instrument; it consists simply of a circle of tin $4\frac{1}{2}$ inches in diameter, on which is pasted a piece of white paper divided into 60 minutes, like a clock-face. The second-hand is taken off, the dial put on the axis and tacked to the support, *B*, and the second-hand is then replaced. Care should be taken that the hole in the dial through which the axis passes is so large that there is no friction when the cog-wheel is in motion. Between the upright posts is a small electro-magnet, *E*, $3\frac{1}{4}$ by 2 inches, wired firmly to a wooden base and to a short post, *F*. In front of the poles of the magnet is an armature, *T*, made of soft hoop iron $\frac{1}{16}$ of an inch thick and 2 by $1\frac{1}{4}$ inches in size. To the lower corners of this armature are soldered two pieces of wire running out horizontally, with their ends filed to points which play in small holes in pieces of sheet brass which are fastened to the inner sides of two small wooden supports, only one of which, *G*, is shown in the diagram. To the soft iron armature is soldered an upright piece of sheet-brass, *H*, 1 by 4 inches in size, with an arm, *I*, also of brass extending alongside the cog-wheel. The extent of the movement of the armature is regulated by the screw, *J*, passing through a small wooden post, and having on its inner end a piece of rubber against which the armature is drawn back by the spring, *K*, the tension of which is regulated by raising or lowering the pin, *L* (a $2\frac{1}{4}$ inch brad), which passes into a binding post not shown in the diagram. A piece of string connects the top of the pin with the spring.

At the end of the brass arm, *I*, is a small brass clip, *M*, hung on an axis coming out at right angles to *I*. When the current is sent through the magnet the lever arm comes forward and the clip, *M*, striking a cog turns the wheel, while the small piece of tin, *O*, is so soldered to the arm as to go down between two cogs and prevent the clip from moving the wheel forward more than one cog at a time. Above the

clip is soldered at right angles to the arm, *I*, a small piece of tin around which is wound a small rubber band, *P*, which by its pressure on the clip keeps this firmly pressed down against the cogs, but at the same time does not press so tightly as to prevent the clip being pulled back over the cog behind by the spring when the circuit is broken. A check-spring, *S*, made of a piece of brass spring-wire with a small tin arm at the end presses against the lower side of the wheel and prevents this from moving backward when the spring draws the clip back over the cogs; this check-spring is held in position by a binding post, which allows it to be lengthened or shortened as may be convenient.

The instrument as now described is ready to be attached to the chronoscope. This may be done in several ways. The following has been tried with success. A second wire (the first is described by Sanford) is run down the side of the slower pendulum about as far as *S* in Sanford's diagram, where it dips in a second, independent, mercury trough. This second wire, at its upper end runs along the top of the axis of the pendulum and has its tip bent over so as to dip into a shallow trough of mercury hollowed out of the wood on which rest the brass plates supporting the knife edges. The object of having the wire end in this way is that it may not interfere at all with the swinging of the pendulum; the wire is practically part of the pendulum, the bent end that dips into the mercury offering no resistence to the free swinging of the pendulum. The counting apparatus and a battery are now brought into circuit with the slower pendulum by means of the upper and lower mercury troughs just described. Thus arranged every swing of the pendulum sends a current through the electro-magnet, pulling the armature forward and forcing the clip, *M*, down, pushing the cog forward and turning the second-hand one division of the dial. The current being broken when the platinum point swings out of the mercury in the lower trough the spring, *K*, pulls the armature back, while the check-spring, *S*, prevents the wheel from going backwards with the clip, *M*.

The proper position of the clip, *M*, and of the stop, *O*, must be determined by trial; the clip can first be fastened to the arm, *I*, and then the place for *O* can readily be found, it being so placed that it does not bind against the cog behind when the armature is pulled back. The proper position for the check spring, *S*, and the tension of the spring, *K*, must also be found by trial, and the amount of movement of the armature necessary for the proper turning of the wheel must be regulated by the screw, *J*. A break-circuit key placed in the circuit enables the operator to stop the counting apparatus

the moment the click of the sounder shows that the two pendulums are in coincidence, and the number of the vibrations is then read off the dial.

The lower mercury trough in which the contact is made must be so arranged that the pendulum will swing lengthwise of the trough and not crosswise, in order to give as long a time as possible for the current to overcome the resistance of the magnet, and a strong current is necessary in order to pull the armature quickly away from the spring. The lighter the lever arm, and the more easily the clip works, the less current will be required. One objection to the instrument is that it makes considerable noise when the magnet pulls the armature forward against the poles, but this is obviated to a large extent by placing pieces of sheet rubber over the poles. This feature of the counting-attachment would in no way interfere with the use of the instrument for lecture room demonstrations, but would rather increase its serviceability for this purpose.